UNIVERSITY OF CALIFORNIA
COLLEGE OF AGRICULTURE
AGRICULTURAL EXPERIMENT STATION
BERKELEY, CALIFORNIA

CIRCULAR 355
April, 1943

BOVINE MASTITIS[1]

O. W. SCHALM[2]

Mastitis is an inflammation of the udder, while garget is the changed condition of the milk which often occurs in mastitis. Two types of the disease are recognized, namely, acute and chronic. The acute type is comparatively rare and is characterized by a sudden appearance in one or more of the quarters. In one form of this type, the affected glands are swollen, warm, and often painful, and their secretion is greatly diminished and abnormal. After the swelling recedes, the quarter often is permanently shrunken and may be entirely nonfunctional or produce only a small quantity of watery milk. In another form of acute mastitis, called blue-bag or gangrene of the udder, the affected quarters turn blue or black and the teats become cold, and, if death of the cow does not ensue, the gangrenous tissues slough away and a long period of healing follows. The losses from acute mastitis are immediately apparent; but, since this form of the disease is of infrequent occurrence, it is not so serious an economic problem as the more prevalent chronic type.

Chronic mastitis occurs commonly in dairy herds throughout the world. It is often a hidden disease which may exist in the udder for a considerable period of time without the dairyman being aware of it. Clinical symptoms, such as clots in the milk (garget) and swelling of the udder, may develop at any time during lactation and frequently they first become evident when the cow is being dried-off or when she freshens. A painful swelling of the gland with marked changes in the milk may occur; but, in general, chronic mastitis is characterized by an intermittent appearance of visible particles, such as clots, shreds, and pus, in the first streams of milk, while the remainder of the milk drawn looks normal. As the disease progresses, the milk-secreting cells are gradually replaced by firm scar tissue, which results in a reduced capacity for milk production.

[1] The author wishes to express his appreciation to C. W. Robson for preparing the illustrations used in this circular.

[2] Assistant Professor of Veterinary Science and Assistant Veterinarian in the Experiment Station.

CAUSES OF MASTITIS

The primary cause of either acute or chronic mastitis is an infection of the udder with specific disease-producing bacteria. Several different germs have been incriminated as causative agents, and of these the streptococci and staphylococci are the most important (fig. 1). The streptococci are responsible for the commonly occurring chronic mastitis, and thus they cause between 70 and 90 per cent of all bovine udder troubles. The staphylococci are usually involved in severe forms of acute mastitis

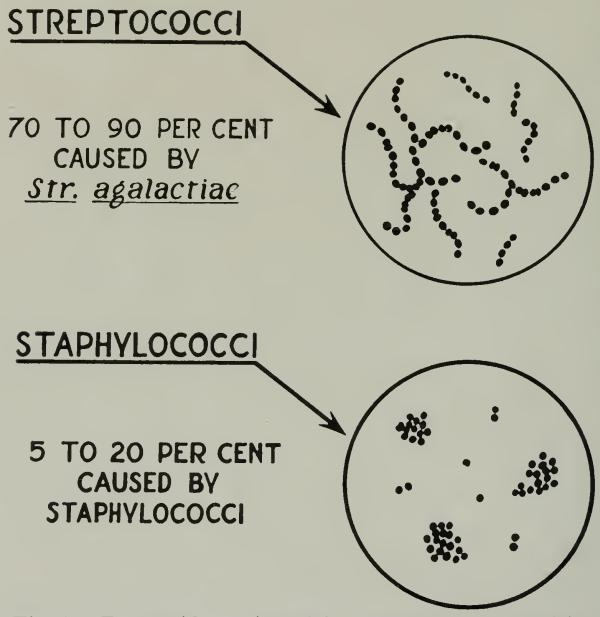

Fig. 1.—Types of bacteria which commonly cause mastitis.

and in gangrene of the udder, but may also cause a mild chronic mastitis. Knowledge is limited concerning the origin, mode of spread, and methods of control of staphylococcic mastitis while, on the other hand, these phases are much better understood with regard to the more prevalent streptococcic type of the disease. The remainder of this circular will be devoted to a discussion of chronic streptococcic mastitis.

The name *Streptococcus agalactiae* has been given to the germ which causes chronic mastitis. It is a specific disease-producing agent which affects only the udder of the cow and has not been found as a permanent inhabitant of any other tissue or organ. It can live in the immature udder of the growing heifer and in the dry udder of the mature cow, as well as in the lactating udder. It does not survive for long periods of time outside the milk gland in the environment of the dairy farm; thus the diseased udder is the reservoir of infection in a dairy herd.

HOW CHRONIC MASTITIS SPREADS

The causal organism, *Streptococcus agalactiae,* gains access to the interior of the udder only through the teat opening, which is controlled by a muscular mechanism called a sphincter (fig. 2). The ease with which the organism can enter a teat depends somewhat upon the efficiency of

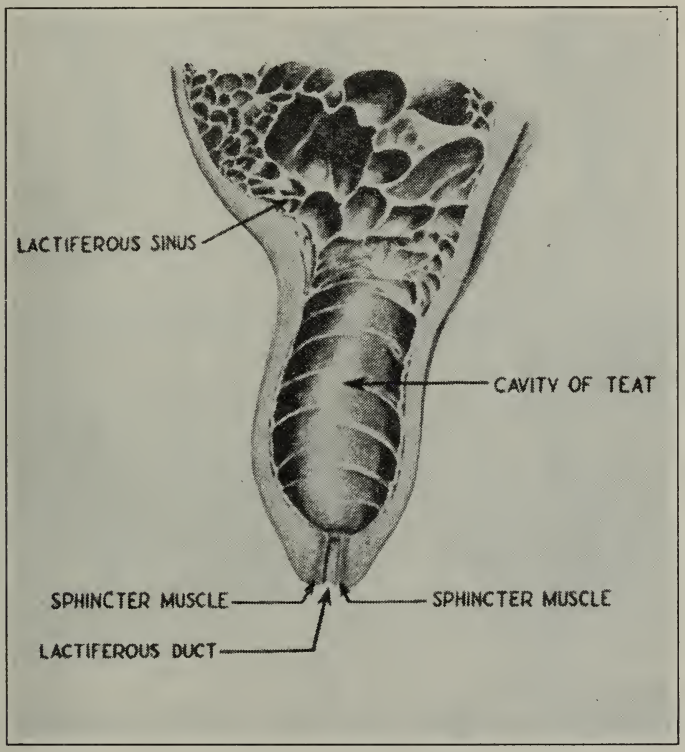

Fig. 2.—Cross section of normal teat and lower portion of mammary gland of cow.

this closing mechanism. Conditions which interfere with proper functioning of the sphincter or favor the retention of bacteria around the teat opening enhance infection with *Streptococcus agalactiae* (fig. 3). Injured teats very quickly become infected. It is important, therefore, to remove loose barbed wire and jagged boards from corrals, pastures, and barns; and in parts of the country where cows are kept inside during the winter, the stalls should be constructed in a manner to prevent as far as possible the occurrence of stepped-on teats.

Since the streptococci enter the udder by way of the teat, the most favorable time for mastitis to spread is during milking. The germs are shed in the milk of the infected cows and are carried to the teats of other

animals on the hands of the milker or on the cups of the milking machines (fig. 4). In a diseased herd where no effort is made to milk the infected animals last, the streptococci are carried from cow to cow at every milking. In such an environment, sooner or later in the lifetime of every cow, conditions will arise that favor the penetration of the germ into one or more quarters of its udder.

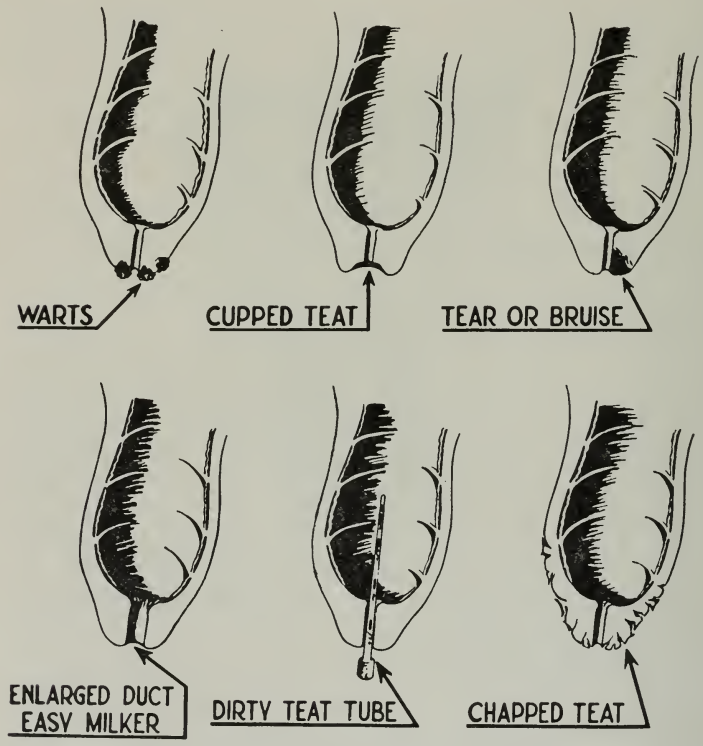

Fig. 3.—Predisposing causes of mastitis.

While the milking act provides the most important channel for the spread of mastitis, infection may take place to a limited extent through association of infected and clean cows in muddy and unsanitary corrals and by flies carrying the streptococci to the teats after having fed on infected milk (fig. 4). Heifer calves, fed milk from infected cows, may transmit the streptococci to the udders of their penmates if permitted to suck each others' teats. The streptococci usually remain dormant in the infected immature udder and, when the heifer freshens, they are shed in the milk; this may or may not immediately be accompanied by visible symptoms of the disease. In one infected herd, where unrestricted sucking occurred among the calves, 6 per cent of the heifers were shedding *Streptococcus agalactiae* when they freshened.

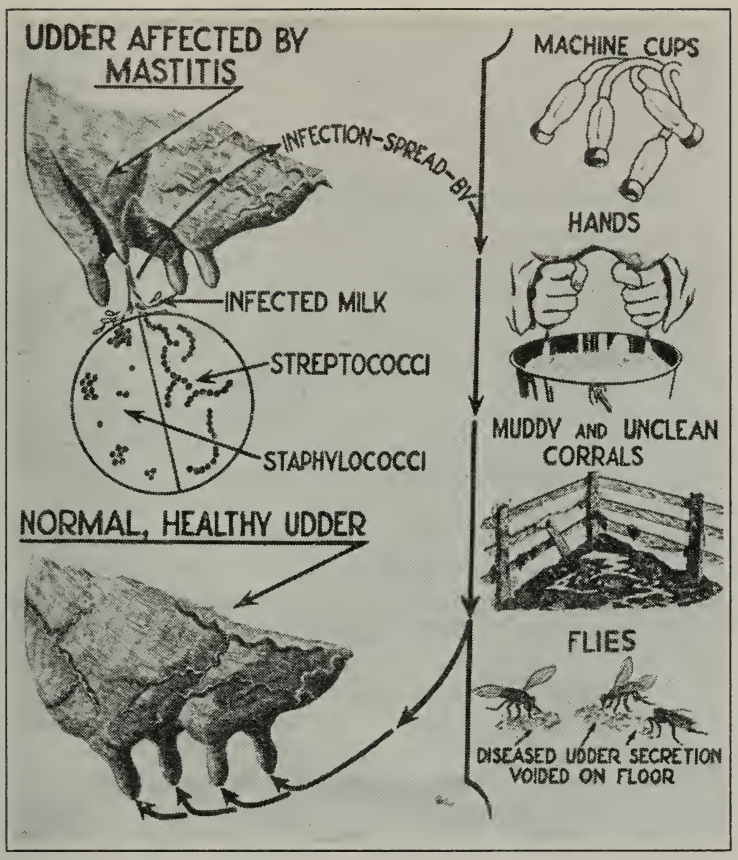

Fig. 4.—How chronic mastitis is spread.

INCIDENCE AND PERSISTENCE OF STREPTOCOCCUS AGALACTIAE IN THE BOVINE UDDER

In 24 California dairy herds totaling 2,346 cows, in which little or nothing had been done to control mastitis, the incidence of infection with *Streptococcus agalactiae* varied from 7.0 to 75.0 per cent in individual herds, with an average infection of 53.2 per cent. The percentage of infection was found to increase with the lactation period as follows:

Lactation period	Percentage infection
First	25
Second	34
Third	55
Fourth, and subsequent	84

When an udder first becomes infected, if the number of organisms entering a quarter is small, the infection may be thrown off without garget

or other symptoms becoming evident. In the average dairy herd, however, this seldom occurs, for the cow is constantly being subjected to reinfection. As a result, approximately 85 per cent of the cows, after once becoming infected, will harbor the germ throughout life and, at any time, it may cause garget to appear.

FACTORS INFLUENCING THE SEVERITY OF MASTITIS

Incomplete Milking.—While infection of the udder with *Streptococcus agalactiae* is the basic cause of mastitis, certain physical factors play an important role in determining the severity of the disease. One of the most important of the extrinsic factors is thoroughness of milking. Failure to strip after machine-milking or incomplete hand-milking of *infected* cows will have a tendency to aggravate the disease and thus bring on more frequent and severe attacks of garget. On the other hand, incomplete milking of udders free from infection will not cause mastitis to appear.[3] A dairyman, therefore, should carefully consider the temperament and reliability of each individual he employs as a milker, for the manner in which infected cows are milked will have a definite tendency toward influencing the seriousness of mastitis in the herd.

Improper Drying-off.—Cows with disease-free udders can be dried-off abruptly without danger of injuring the udder or inducing mastitis. However, drying-off infected cows too rapidly will frequently cause a flare-up of the infection and, as a result, the diseased quarters often become swollen and filled with pus.

Effect of Unfavorable Weather.—In California dairy herds, which are usually kept outside all year, mastitis is often more serious in winter than during other seasons, because exposure to rain and mud tends to aggravate the infection and bring on attacks of garget. Many California dairymen have erected storm sheds, which should aid materially in preventing an increase in the severity of mastitis in their herds during winter.

Effect of Excessive Vacuum in Milking Machines.—If milking machines are operated with a vacuum greater than that recommended by the manufacturer, there is danger of injuring the delicate udder tissue. In the case of infected udders, such a procedure tends to cause an acute flare-up of the disease. Also, milking machines operated at the proper suction but left on too long may aggravate the disease.

[3] Two dairies, milking a total of over 350 cows by machine without stripping afterwards, have been closely studied by the writer over a two-year period. It was observed that stripping can be eliminated after adequate machine-milking in the case of noninfected cows without danger of inducing mastitis or lowering production. In the presence of *Streptococcus agalactiae,* however, and to a lesser extent with staphylococcic infections, there was a definite tendency for garget to develop when nonstripping was practiced. Dairymen desiring to initiate nonstripping in their herds should limit the practice to cows with noninfected udders. Such animals can be selected with certainty only by bacteriological procedures, such as the microscopic test for mastitis as described in another section of this circular.

DIAGNOSIS OF MASTITIS

To control mastitis, it is necessary to detect all of the infected cows in a herd so that they may be properly segregated and treated. Since many infected animals do not constantly show visible symptoms of mastitis, special tests for evidence of infection must be employed. Certain "barn tests" have been advocated, such as using a strip-cup[4] for an examination of the first streams of milk for shreds, clots, or other visible particles, testing the first milk with a color indicator to determine whether it is acid or alkaline (bromthymol blue test), and palpation of the milked-out udder for scar tissue. These tests depend for positive results on the existence of sufficient tissue damage to render the milk or the udder tissues abnormal. Since the extent of injury to the udder varies with the stage of infection, these tests fall short of the goal of detecting all of the infected animals in a herd. Their efficiency as indicators of mastitis can be greatly increased, however, by using two or more of them in combination to test the herd at frequent intervals. Special training is necessary to use and interpret the bromthymol blue test and palpation of the udder for scar tissue. On the other hand, the strip-cup test does not require special skill and if a dairyman will use this frequently and keep a record of the animals showing visible particles in their foremilk, he will be able by this simple procedure to identify many of the infected cows.

The most accurate procedure for finding the infected cows is to make a complete bacteriological analysis of the milk of each animal for the specific identification of *Streptococcus agalactiae*. However, such a study is costly and, therefore, impractical for use as a routine procedure in the average herd.

Examination of the milk by means of a microscope to determine whether it contains streptococci or staphylococci is a practical and fairly reliable test for mastitis infection. A disadvantage of the microscopic test is that harmless streptococci sometimes get into the udder and are shed in the milk and it is not possible to differentiate them from disease-producing streptococci by their appearance under the microscope. These harmless streptococci often are unable to persist in the udder for any great length of time and thus milk drawn for test at a later date will usually be free of the organisms. On the other hand, cows infected with *Streptococcus agalactiae* as a rule shed this organism at every milking and, therefore, the microscopic test will be positive for streptococci whenever a sample is taken. Although this test has its limitations, it can be very valuable in the diagnosis of mastitis when properly used.

[4] A strip-cup is a container fitted with a removable 100-mesh screen. By drawing the first streams of milk into the cup through the screen, solid particles that may be present in the milk will be held back by the screen and thus they can be detected readily.

PROCEDURE FOR USE OF THE MICROSCOPIC TEST IN MASTITIS CONTROL [5]

To keep mastitis under control in a herd, it is necessary to establish a program of *regular and frequent testing* of the cows for evidence of streptococci in their milk. For this purpose, the microscopic test can be used to advantage and without too great expense. The milk samples must be collected with the utmost care in order to avoid contamination with bacteria from outside the udder. Each teat must be washed free of dirt and wiped with a clean cloth or pledget of cotton soaked in a suitable disinfectant.[6] Immediately thereafter, a stream of milk should be drawn from each teat into a sterile sample bottle, which should be closed as quickly as possible to avoid contamination from the air. It is important that each sample be properly identified with the number or name of the cow. The samples are incubated for from 15 to 18 hours at 37° C, after which smears are prepared for microscopic study.

When a mastitis control program is started in a herd, the microscopic test should be made at monthly intervals for the first 3 months. The data thus accumulated will provide a sound basis for an initial classification of the cows. Thereafter the noninfected and doubtful cows should be checked by microscopic test every 3 months until such time as the results obtained in the control of the disease indicate that the interval between tests may be increased.

The key for use in classifying the cows is as follows:

Group 1: Cows free of infection—

Animals with a negative mastitis history and a negative microscopic test.

Group 2: Cows under suspicion—

Streptococci unassociated with an increase in leucocytes found, on the first microscopic test, in cows with no history of mastitis.

Streptococci unassociated with an increase in leucoctyes found for the first time in a cow previously negative to the microscopic test and which has no history of mastitis. (May be classified as negative again if the next two microscopic tests show no streptococci.)

Microscopic test fails to reveal infection, although there is a history of mastitis in the past.

Many staphylococci found, unassociated with a mastitis history.

[5] The Veterinary Science Division of the College of Agriculture at Berkeley will assist dairymen, through veterinarians and county farm advisors, to organize milk improvement associations for the control of mastitis. Such a program would be largely based upon the tests described in this section.

[6] Disinfectants having a strong odor, such as the coal-tar products, should be avoided, for they may affect the flavor of the milk. Chlorine has been found to be satisfactory. A freshly prepared solution containing approximately 400 parts per million of available chlorine is desirable. Chlorine compounds, with directions for the preparation of solutions containing a known volume of available chlorine, may be obtained from dairy-supply houses.

Group 3: Cows positive for mastitis infection—

Streptococci found in cows with a mastitis history.
Streptococci accompanied by an increase in leucoctyes.
Streptococci found repeatedly in cows with no mastitis history.
Staphylococci found in cows with a mastitis history.

Classification of the cows should be started as soon as the results of the first test are obtained. Group 1 cows should be milked first, group 2 cows next, and those of group 3 last. The teats of cows in groups 1 and 2 should be disinfected after each milking in the manner described elsewhere in this circular. After a cow is classified as positive for mastitis, it need not be tested again by the microscopic test until after it has been treated.

TREATMENT OF MASTITIS

Up to a few years ago, mastitis was considered to be an incurable disease. When sulfanilamide was discovered, it was hoped that this drug would prove to be effective against the forms of the disease caused by streptococci and by staphylococci. Carefully controlled studies, however, have revealed that the sulfa drugs, given by mouth and even in excessive amounts, seldom destroy all of the mastitis germs within the udder. Sulfanilamide, however, when administered in sufficient amount and over a long enough period of time, will retard the multiplication of the organisms in the udder. This drug, therefore, is useful in the treatment of acute mastitis and, when used in conjunction with massage and frequent milking-out of the udder, will often hasten recovery from the acute symptoms of the disease.

It has been learned in recent years that from 50 to 90 per cent of the cows infected with *Streptococcus agalactiae,* the cause of chronic mastitis, may be completely cured by injecting specific chemical agents into their infected quarters. Three of these—neutral acriflavine, colloidal silver oxide, and tyrothricin—are now available to the veterinarian.

The percentage of cures that may be effected in a herd depends in a considerable measure upon the severity of the disease. In general, cows with udders showing little or no damage are more readily cured than cows with badly scarred ones, although many of the latter will respond to treatment.

After the infection has been removed, the udder will show a tendency to rebuild itself so that in subsequent lactations it may revert to normal. Cures may be produced by treating either during lactation or during the dry period. The therapeutic agents available at the present time are irritating and, when injected into the lactating udder, cause the milk to become abnormal and render it unfit for use for from several days to 2 weeks. In some instances, treatment during lactation will cause a diminished production for the remainder of that period. As a result of dilution of the therapeutic agent by the milk, more treatments may be necessary to bring about a cure during lactation than during the dry

period; therefore, it is probably more economical to administer the treatment when the udder is dry. A disadvantage in applying the treatment to the nonfunctioning udder is that, in a small percentage of cases, chemical irritation is excessive and, as a result, the teat canal becomes closed by scar tissue. This seldom happens with the lactating udder.

In spite of some loss from diminished production during a current milking period or the destruction of an occasional quarter from excessive chemical irritation, the treatment of infected cows, whether applied during lactation or during the dry period, will be of considerable help in reducing the amount of infection with *Streptococcus agalactiae* in the herd; and as a result, many cows will be saved from premature slaughter because of diseased udders. Treated cows, however, must not be regarded as cured until proved to be free of streptococci by the microscopic test.[7]

The successful treatment of mastitis with the chemotherapeutic agents thus far discovered has stimulated a search for more effective and less irritating products, and it is probable that even better treatments for mastitis will eventually be developed.[8]

Cows cured of mastitis by chemotherapy are susceptible to reinfection, and it is important, therefore, before treatment is used in a herd, to establish a program designed to stop the further spread of the causal organism.

CONTROL OF THE SPREAD OF STREPTOCOCCUS AGALACTIAE

Based on the foregoing discussion of chronic mastitis and the classification key, the following procedures for controlling the spread of this disease in a herd are essential:

1. Feed calves pasteurized milk; or, if raw milk is fed, prevent them from sucking each others' teats.
2. Milk the cows in proper sequence according to the condition of their udders. If they have been classified by microscopic test, milk the group 1 cows first, group 2 next, and group 3 last. If it is not feasible to apply the microscopic test for mastitis to the herd, then classify the cows as noninfected, doubtful, or positive on the basis of strip-cup findings and their history with regard to this disease.
3. After each milking, disinfect the teats of the group-1 and group-2 cows by immersing them in a freshly prepared solution containing from 250 to 400 parts per million of available chlorine. A cupful of this solution should be used for each udder, after which it should be discarded.[9]
4. In the intervals between testing the herd by microscopic test, it is advisable to use a strip-cup daily on the group-1 and group-2 cows to examine the first streams

[7] Milk the treated animals in group 2 until it is determined by microscopic test whether or not they have been cured.

[8] Recently a report was released by investigators at another experiment station, in which it was stated that a high percentage of cures from infection with *Streptococcus agalactiae* was obtained by four daily injections of sulfanilamide in oil into the diseased quarters.

[9] See footnote on page 8 regarding preparation of chlorine solutions.

of milk for the presence of visible particles. A cow previously classified as negative but found to be producing gargety milk should be milked with the group-2 animals. If the condition persists, she should finally be placed in group 3.

5. Do not reclassify cows on the basis of an apparent recovery from visible mastitis in the absence of treatment, for such animals are usually still infected and are shedding streptococci in their milk.
6. Do not milk abnormal udder secretions on the floor as this tends to spread the infection.
7. Milk by hand the cows that show garget and practice complete milking. Give them the best care possible.
8. Eliminate the infection as rapidly as feasible by having a veterinarian treat the positive animals and by selling, for slaughter, the cows proving to be incurable. Treatment is not practical unless the foregoing suggestions for controlling the spread of the disease in the herd are put into practice.

WHY DAIRYMEN SHOULD CONTROL MASTITIS

The eradication of chronic mastitis from a dairy herd should:

1. Increase the average milk production per cow and, thereby, increase the financial returns from the herd.
2. Lengthen the productive life of the dairy cow, with fewer animals going to the butcher because of diseased udders.
3. Improve the quality of the milk through lower bacterial counts and improved flavor.
4. Make it safe to omit hand-stripping after machine milking.
5. Permit the use of a walk-through milk barn in which hand-stripping can be eliminated. In certain types of walk-through barns with a pipe-line milking machine, it is possible for a skilled laborer to milk 150 to 200 cows in approximately the time required for milking 30 cows by hand or 60 cows with the bucket-type milking-machine, followed by stripping.
6. Make it safe to dry-off cows abruptly.

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